MOS TRANSISTOR AND METHOD OF MANUFACTURING A MOS TRANSISTOR

[0001] In base stations for personal communications systems (GSM, EDGE, W-CDMA), the RF power amplifiers are the key components. For these power amplifiers, RF Metal Oxide Semiconductor (MOS) transistors are now the preferred choice of technology, because these are able to provide for excellent high power capabilities, gain and linearity. These MOS transistors are not only used in base stations but also in radar and broadcast applications. Broadcast applications have a higher power level and a lower load resistance than base station applications. A way to increase the load resistance is by enabling a high supply voltage operation. The advantage of a higher supply voltage and a higher load resistance is that the output circuitry matching at higher supply voltages is less critical. This results in a more reliable circuit (with less heating of the matching components) and in amplifiers with a power above 300W, which is requested by the market. These matching advantages and power advantages in broadcast applications are also applicable for base station applications.

[0002] For broadcast applications the bandwidth is a crucial parameter, requiring a typical bandwidth of 450 MHz (450-900 MHz operation range) for Ultra High Frequency (UHF) and about 200 MHz for Very High Frequency (VHF) applications. The UHF value is about a factor of 10 larger than for the W-CDMA signals that are typical in base station applications. Another important parameter for broadcast applications is ruggedness, which is the ability of the MOS transistor to withstand a mismatch condition at a certain power level. The ruggedness requirement of the MOS transistor used in broadcast applications is more severe than the standard requirements for ruggedness in base station applications, because the MOS transistor used in broadcast applications should be able to withstand a switching at a high power level. To fulfill this more severe ruggedness requirement for broadcast applications, the lateral breakdown voltage in the MOS transistor should be more than 20% above the maximum applied drain voltage, which is about twice the supply voltage.

[0003] In WO 2005/022645 an LDMOS (Laterally Diffused MOS) transistor is disclosed, which is provided on a semiconductor substrate comprising a source and a drain region, that are mutually connected through a laterally diffused channel region, and a gate electrode for influencing an electron distribution in the channel region. The drain region comprises a drain contact region and a drain extension region extending in the semiconductor substrate from the drain contact region towards the channel region. A shield layer with a stepped structure is provided between the gate electrode and the drain contact region extending over a part of the drain extension region to shield a part of the gate electrode and the drain region.

[0004] The lateral breakdown voltage of an MOS transistor is defined as the drain voltage, while applying zero volts on the gate and the source, for which the drain to source current is larger than a specific (low) value, for example 0.01 mA per mm gate width. Typically the lateral breakdown voltage of this LDMOS transistor, which is used in base station applications, is around 70V to 75V at a supply voltage of 32V. However the lateral breakdown voltage of the LDMOS transistor, which is used in broadcast applications at a higher supply voltage of 40V, should be more than 88V to provide the required ruggedness for broadcast applications. Hence, the disadvantage of the known LDMOS transistor is that it does not fulfill the required ruggedness requirement for broadcast applications.

[0005] It is an object of the invention to provide a MOS transistor that fulfills the ruggedness requirements for broadcast applications. According to the invention, this object is achieved by providing a MOS transistor as claimed in claim **1**.

[0006] The shield layer of the MOS transistor according to the invention is of an electrically conductive material and extends at least over a part of the drain extension region. A distance between the shield layer and the drain extension region increases in a direction from the gate electrode towards the drain contact region, the shield layer thereby influencing the distribution of the lateral electric field in the drain extension region in such a way that the lateral breakdown voltage of the MOS transistor is increased to a level at which the MOS transistor may fulfill the ruggedness requirement for broadcast applications for a supply voltage higher than that used in base station applications. Furthermore, it appears that also the bandwidth requirements for broadcast applications may be met by the MOS transistor according to the invention.

[0007] In an embodiment of the MOS transistor according to the invention, the shield layer comprises a multiple of portions extending over the drain extension region essentially parallel to a top surface of the drain extension region, in which a second distance between the drain extension region and a second portion of the shield layer is larger than a first distance between the drain extension region and a first portion of the shield layer, which first portion is closer to the gate electrode than the second portion of the shield layer. This embodiment allows for easy and simple fabrication of the MOS transistor according to the invention.

[0008] In another embodiment of the MOS transistor according to the invention, the shield layer comprises a multiple of stacked shield sub-layers, in which a second shield sub-layer extends over a first shield sub-layer and is separated from the first shield sub-layer by an isolation layer, and in which the second shield sub-layer extends over a larger part of the drain extension region than the first shield sub-layer. Furthermore a second distance between the second shield sub-layer and the drain extension region is larger than a first distance between the first shield sub-layer and the drain extension region. This embodiment provides for an even simpler fabrication of the MOS transistor according to the invention.

[0009] In an embodiment of the MOS transistor according to the invention the shield layer also extends over a part of the gate electrode. In this way it is ensured that the shield layer extends over a part of the drain extension region that is adjacent to the gate electrode, without being influenced by the accuracy of the fabrication method that determines the exact position of the shield layer with respect to the gate electrode.

[0010] In another embodiment the shield layer also extends over a part of the source region. This enables to provide for an electrical contact on a part of the shield layer that extends over the source region.

[0011] In an embodiment, the MOS transistor further comprises a substrate contact region, which is adjacent to the source region, wherein the substrate contact region and the source region are electrically connected via a first interconnect layer. This embodiment enables a low resistance electri-